FRED Reports

SUSTAF SALMONID EGG SORTING MACHINE WORKSHOP
--PROCEEDINGS--
BY
Bernard M. Kepshire
Number 10

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

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Enhancement & Development

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P.O. Box 3-2000
Juneau, Alaska 99802

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ABSTRACT

The Sustaf 10^6, a highly efficient machine used for separating live from dead salmonid eggs, has become popular at Alaskan hatcheries. A workshop was organized to enhance the efficiency of the Sustaf itself and personnel using the Sustaf. The workshop dealt with three topics:

1) The theory, mechanics, and maintenance of the Sustaf.

2) Disinfection of the Sustaf to reduce the spread of fish diseases.

3) Practical use of the Sustaf which included:

   a) Improved egg capacity with an auxiliary egg hopper.

   b) Tips for increasing the egg sorting efficiency of the Sustaf.

   c) Addition of an electronic live egg counter to allow very rapid and accurate sorting and counting of eggs.

INTRODUCTION

The separation of live from dead salmonid eggs is a routine procedure at hatcheries. This procedure is necessary for two reasons:

1) Prevent the spread of fungus from dead to live, eyed eggs.

2) Accurately inventory the eyed eggs.

Various techniques for sorting eggs, i.e. separating live from dead eggs, exist, ranging from hand picking of dead eggs with a syringe and glass tube to machines which electronically sort the eggs.

The Sustaf 10^6 is the most rapid egg sorting machine available. This machine can sort up to 1,000,000 eggs per hour under ideal conditions. This machine was originally developed for the Italian private trout hatcheries. The first Sustaf 10^6 in Alaska was used in October 1980.

A workshop was held on March 18, 1982 to enhance the efficiency of the Sustaf egg sorting machine and personnel using the Sustaf. These goals were met because of the interaction among the 18 workshop attendees. It was a day well spent.

These proceedings consist of three workshop sections:

1) Theory, mechanics, and maintenance.

2) Disinfection.

3) Practical use.

It is my hope that these proceedings will be of use to those who were unable to attend the workshop as well as those who attended.

Bernard M. Kepshire
March 7, 1983

THEORY, MECHANICS, AND MAINTENANCE

The two types of Sustaf egg sorting machines are the Sustaf 10^6 and Sustaf-mini. The Sustaf 10^6 and Sustaf-mini can sort up to 1,000,000 and 200,000 eggs per hour, respectively. This workshop primarily dealt with the Sustaf 10^6.

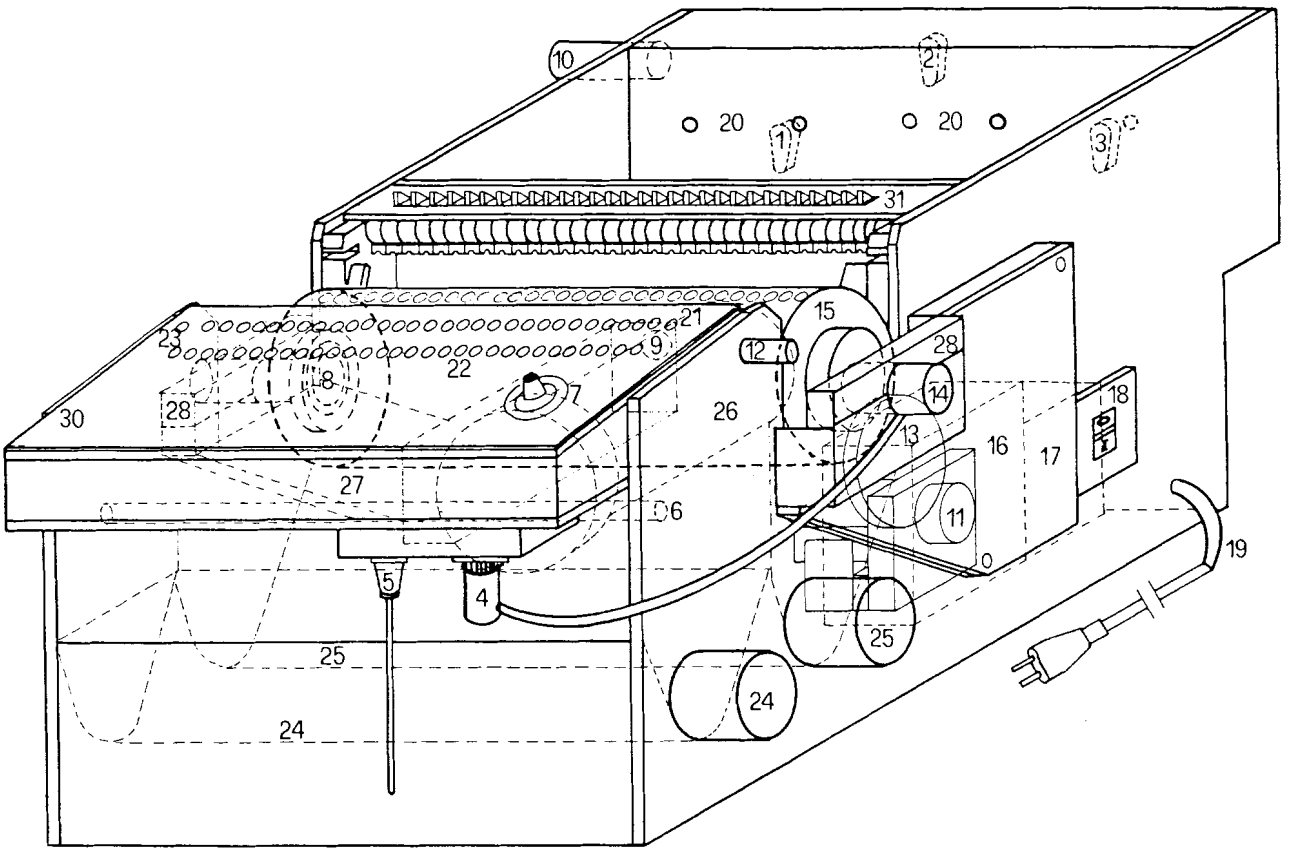
Mr. Starr Busch and Mr. Bill Townsend presented this section of the workshop. A Sustaf 10^6 egg sorting machine was thoroughly examined.

In simplest terms, the Sustaf works as follows. Shocked salmon or trout eggs loaded into the egg basin (Figure 1) flow with water into the drum holes. Looking at the drum on the ignition lock switch (on-off switch) side of the Sustaf (Figure 1), each egg moves in a counter-clockwise direction to a light emitting diode (LED). The light hits the egg and bounces back to a detector if the egg is dead. At the 9 o'clock position, a pulse of air blows any dead eggs into the ejected egg discharge canal (Figure 1). At the 6 o'clock position, i.e., bottom of the drum, all live eggs are blown via a constant jet of air into the good egg discharge canal (Figure 1). Not all unfertilized eggs will turn white after shocking. Some, called blank eggs, will remain clear and be sorted with live eggs. The Sustaf will not differentiate between live and blank eggs.

Across the top of the Sustaf 10^6 next to the drum are more LED's, a row of 30 red LED's and a row of 30 green LED's. Each red LED and the green one closest to it correspond to one of the 30 rows of holes around the circumference of the drum. This is easy to see on the machine, because the red and green LED's are in line with their corresponding row. By observing the sequence in which the red and green LED's light up, the operator can ascertain whether the sorter for that particular row is working properly. The machine is operating properly when a red light is followed by a green light. A red light indicates detection of a bad egg; a green light indicates ejection of the egg. If this sequence does not occur, eggs carried in that row are being mis-sorted. The operator can block eggs from entering that row by turning one of the levers on top of the machine. These levers are located on the opposite side of the drum from the red and green LED's, and there are 30 of them, one for each row of holes around the drum.

The LED's that transmit light to the eggs emit infra-red light. These LED's will not burn out. Overhead lights and flashlights apparently do not adversely affect these LED's. However, direct sunlight must be avoided! Use Q-tips and camera lens cleaner to clean these LED's and detectors after daily use of the Sustaf.

The sensitivity of the LED's that transmit light to the eggs is controlled through two circuit boards located inside the machine under the sensitivity regulator (dial) (Figure 1). When the circuit boards are correctly adjusted, a setting of between 1.5 and 7 on the dial will provide the best egg sorting accuracy. A setting below 1.5 puts most eggs, dead or alive, into the dead egg discharge canal, while a setting above 7 increases the number of dead eggs going into the live egg discharge canal.



1. Drum cleaning regulation tap
2. Regulation tap for egg basin water
3. Water cleaning regulation tap
4. Station ejection connector
5. Feeding connector
6. Cleaning unit for ejected eggs canal
7. Sensitivity regulator
8. Water lubricated plastic bearing
9. Compressor air-intake
10. Water feeding pipe
11. Drum driving motor
12. Station dowel pin
13. Drum movement transmission
14. Ejection unit for unusable eggs
15. Perforated drum for egg transport
16. Feeding transformer unit
17. Feeding stabilizer
18. Ignition lock switch
19. Feeding cable
20. Egg basin
21. Red LEDs - visualization control
22. Green LEDs - ejection control
23. LED - control gauge
24. Discharge canal for ejected eggs
25. Discharge canal for good eggs
26. Air compressing motor
27. Ejector air pipe
28. Drum fixing supports
30. Visualization and ejection control station
31. Drum cleaning unit

Figure 1. Sustaf 10^6 schematic.

Although the two circuit boards are safe to handle, they are very sensitive and should be adjusted only by an authorized repairman. Repairmen must remember to use a plastic, not metal, screwdriver when making adjustments.

After adjustments are made, the boards must be sealed so the electronic parts don't break if bumped. Circuit board settings do not have to be changed for eggs from different salmonid species; a given sensitivity regulator setting works for all species. Field personnel should carry spare, previously adjusted circuit boards and insert them if the machine malfunctions. The circuit boards are exposed by removing the top plate of the machine. They should slide out easily for replacement. Circuit boards' schematics and parts list are in Appendix A.

The power supply is exposed by removing the bottom plate of the Sustaf. There are two fuses with the power supply. Troubleshooting is aided by noting which fuse, if any, has blown. Leave troubleshooting to an authorized repairman. Power supply wiring diagrams, schematics, and parts lists are in Appendix B. All Sustafs shipped to the United States are wired for 110 volts AC.

Electric power fluctuations will damage the machine, especially fluctuations greater than 10%. The cheapest, most effective solution is a constant voltage transformer. The Sustaf will not work when plugged into a ground fault interrupter (GFI) circuit. The machine is well insulated so the user should not have a "shocking" experience.

The drum can be disassembled to expose the egg ejectors or replace the "skin," i.e., the black perforated surface that holds the eggs, in case the drum malfunctions. Before disassembling the drum, make an alignment mark between the skin and drum edge. It is absolutely necessary that the holes in the skin line up exactly with the egg ejectors in the center of the drum when the skin is replaced. Each ejector flapper is controlled by an electromagnet. These ejectors can become plugged with debris so check them routinely. If an ejector fails, it can be replaced easily in the field.

The performance, i.e., breakdowns, of the Sustaf was assessed. Mr. Bill Townsend has used a Sustaf for two years (11 months per year) to sort millions of rainbow trout eggs. During this period, Bill replaced one blower and some ejectors. Spare parts that can be replaced by field personnel are as follows:

Adjusted circuit boards
Fuses
Egg ejectors (electromagnets and flappers)
Blower
Vacuum motor
Gear drive motor
Power supply (pack)

DISINFECTION

Dr. Joe Sullivan presented this section on disinfection of the Sustaf.

The Sustaf is very difficult to disinfect. The entire machine cannot be heated to 70°C for 4 hours, so disinfect the wet parts, not electronics parts, with 200 ppm Betadine or 200 ppm active chlorine for a 30 minute exposure time. Disinfect the machine each time a different species' or stock's eggs are sorted.

Two ways to reduce the entry of disease organisms into the Sustaf are:

1) A filter now comes with the vacuum pump. Soak this filter in Betadine, wring it out and reassemble.

2) The air intake is close to the bottom of the Sustaf and as such may bring in moisture laden with disease organisms. Therefore, route the air intake via clothes dryer hose to the outdoors, or hang the back of the Sustaf 5 cm over the edge of the table since tables in hatcheries are usually wet.

The best way to reduce disease transfer between hatcheries is to buy a machine for each hatchery and never move it to another! All machines purchased for a sockeye hatchery must never be transported to another hatchery.

Further information regarding disinfection of Sustaf machines may be obtained from:

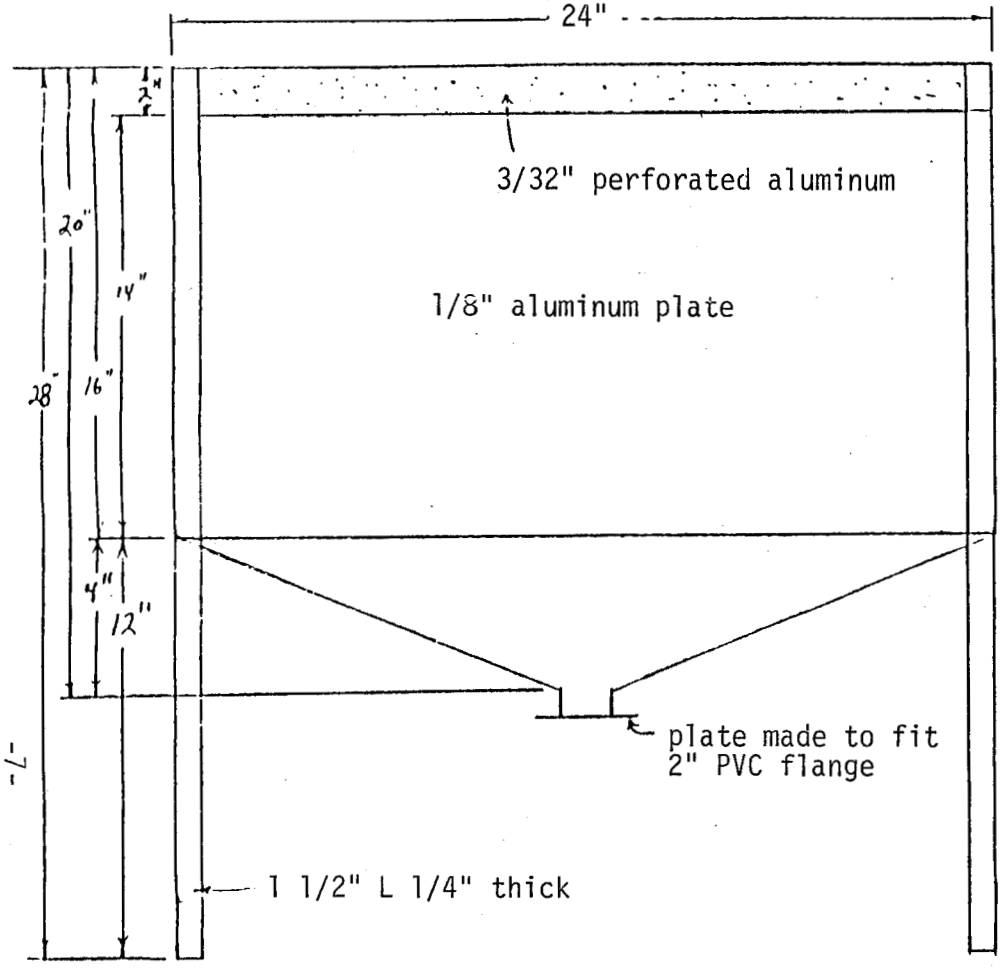
Dr. Roger S. Grischkowsky
Principal Pathologist
Alaska Department of Fish and Game
FRED Division
333 Raspberry Rd.
Anchorage, Alaska 99502
Telephone: (907) 267-2244

PRACTICAL USE

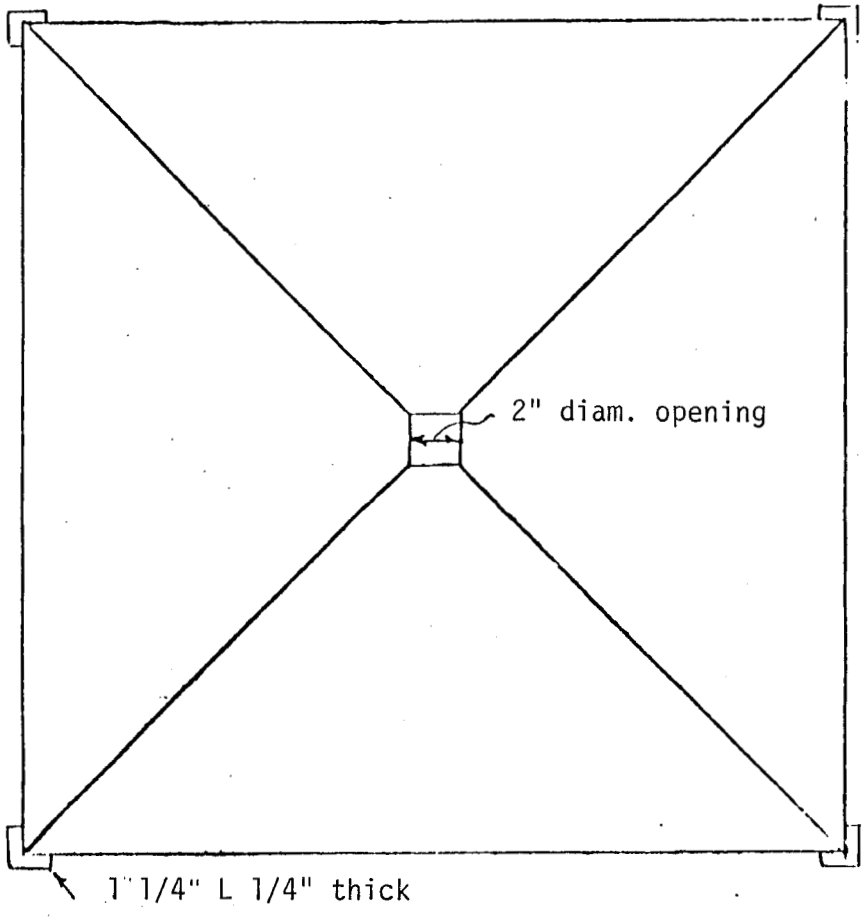
Auxiliary Egg Hopper

Mr. Dail Hurdlow, Hatchery Manager for the Prince William Sound Aquaculture Corp., has designed a useful large capacity, moveable egg hopper (Figure 2) for the Sustaf machine, which has a very small egg basin. Shocked, eyed eggs are siphoned from incubators via tygon tubing (note clamp for holding tubing in Figure 3) into the aluminum hopper. The egg hopper table (Figure 3) is then moved over to the Sustaf. Eggs flow via tygon tubing from the bottom of the hopper into the Sustaf egg basin. The perforated aluminum around the top of the hopper prevents egg overflow. For more detailed information, contact Mr. Hurdlow at:

Port San Juan Hatchery
Prince William Sound Aquaculture Corp.
P.O. Box 1110
Cordova, AK 99574
Telephone: (907) 424-7511



side view



top view

Egg Hopper for Sustaf

1) There needs to be at least a 3" drop from incubator surface level to egg hopper for filling with 1 1/2" diam. tygon.

2) There needs to be at least a 1" adjustment drop on tygon hose from hopper to fill the Sustaf properly.

Figure 2. Auxiliary egg hopper for egg sorting machine.

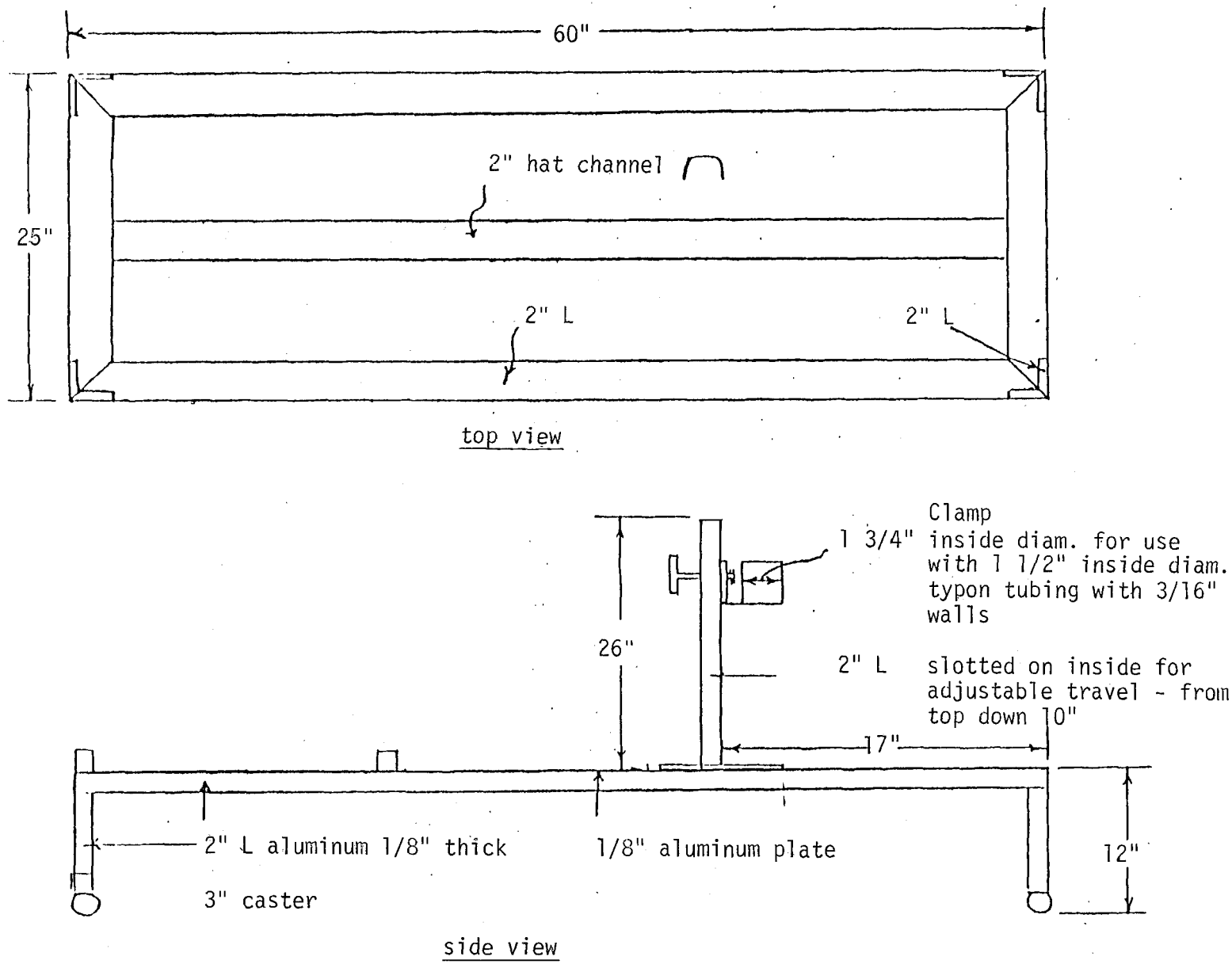


Figure 3. Moveable table for auxiliary egg hopper.

Hatchery Tips

Mr. Bill Townsend has used a Sustaf machine for 2 years, 11 months per year, 6 days per week, and approximately 5 hours per day for sorting rainbow trout eggs. His Sustaf averages 900,000 eggs sorted per hour! With this experience, his practical tips on successfully using the Sustaf were most welcome.

Instead of shocking eggs, Troutlodge personnel salt the eggs to get rid of most dead eggs and especially the fungused egg clumps. This helps the Sustaf sort faster and with better live-dead egg separation.

The Sustaf must warm up for a few minutes prior to loading eggs. Otherwise, poor sorting occurs. Be sure to wear ear plugs while the machine is running, since it is painfully noisy.

Water flow rate, level, and especially water pressure in the water feed line (Figure 1) are vital. A garden hose can be nippled into this line. Water pressure must be 40 lb/in^2 to produce a stream of water so that the eggs upwell into the drum. Load the Sustaf hopper up to 75% of its capacity with eggs avoiding broken eggs and egg clumps. The water level should not exceed the egg level. A drum "comb" for preventing eggs between holes from riding over the drum is not necessary if water requirements are met.

The diameter of the holes in the drum must be slightly larger than the egg diameter. Otherwise poor sorting will result. Experience from Alaskan hatcheries and Troutlodge recommends the following drum hole sizes for each salmonid species:

Species	Drum hole size
pink salmon	medium
chum salmon	medium or large
chinook salmon	large
coho salmon	large
sockeye salmon	medium or small
rainbow trout	medium or small

The LED's and detectors will get water on them if water overflows the drum. This results in poor sorting so be sure to have a lot of Q-tips handy for cleaning.

Electronic Live Egg Counting

Several years ago, Alaskan hatchery personnel discovered that their electronic fish counters [1]/ (Figure 4), counted eyed but not dead or "blank" eggs. Counter accuracy can routinely exceed 99%. This counter is easily set up to count eggs coming out of the good egg discharge canal of the Sustaf.

1/ Available from Northwest Marine Technology, Inc., Shaw Island, Washington 98286. Telephone: (206) 468-2340.

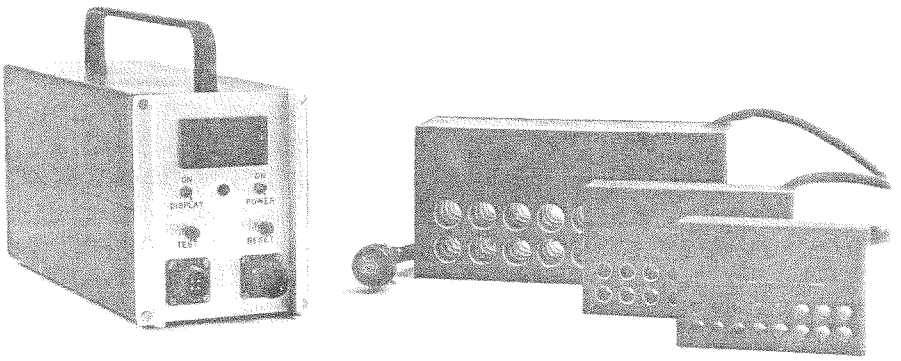


Figure 4. An electronic fish counter.

Mr. Tim Joyce, hatchery manager at the State of Alaska's Kitoi Bay Hatchery, pioneered and described eyed egg counting with the fish counter. According to Joyce, sorted eggs flow in a small trough to a horizontally-positioned counting head. Turbulent water flow next to the counting head enhances the separation between eggs required for accurate counting.

Mr. Irl Palmer, a State of Alaska Fish and Game Technician III, described the very efficient eyed egg counting system used at Snettisham Hatchery during 1981. The following description with figures is based on the memo of October 26, 1981, of Mr. Al Didier, hatchery manager at the State of Alaska's Snettisham Hatchery.

A counting box was constructed from 0.25-inch PVC plate (Figure 5). A counting head was modified by the addition of a 0.25-inch PVC plate on the upstream side of the head. Holes were drilled in the plate to match the hole diameters in the counting head (Figure 5). Spacers and silicone sealant held the plate 2 mm from the head with perfect hole alignment; duct tape reinforced the bond. Vexar screen (0.125-inch mesh) sealed the gap between the counting head and the plate.

The counting head was placed in the box and held in place by water pressure. Water was supplied from three sources. One source is the water that washes the live and "blank" eggs from the good egg discharge canal of the Sustaf. Water was also supplied to the section of the box farthest away from the counting head (Figure 5). Finally, water directed through a slotted plastic tee washed the vexar screen attached to the counting head and plate. Water level in the box, which must be higher than the counting head, was maintained by regulating water flow from non-Sustaf sources and by the position of the overflow perforated plate. Egg and water discharge from the counting unit (counting head and box) was collected in a bucket screened near the top.

The egg sorting and live egg counting process is shown in Figure 6. Eyed eggs were placed into a Sustaf 10^6 for sorting. Live and "blank" eggs from the good egg discharge canal dropped into the counting unit. The live eggs were counted and dropped into a bucket. When the desired number of live eggs for a particular incubator was reached according to the counter display, a dip net was placed next to the counting head to stop the flow of eggs. This provided plenty of time to change buckets, record the number of live eggs, and reset the counter. When counting resumed, the counting head easily handled the accumulated eggs since eggs can be counted much faster than the Sustaf can sort them. Eggs larger than the hole size blocked the hole but were easily removed with an electric razor brush (or the standard head cleaning brush).

The counting unit performed excellently. The design provided the separation required between eggs for accurate counting. The gap between the counting head and plate, as well as the additional water injection from the slotted tee, forced the head to draw water from the gap as well as from the plate. This made a space between all eggs as they proceeded through the plate. Water flow in the gap forced a space between these eggs so that only one egg at a time entered each counting head tunnel. Quality control consisted of comparing hand-counted samples of 100

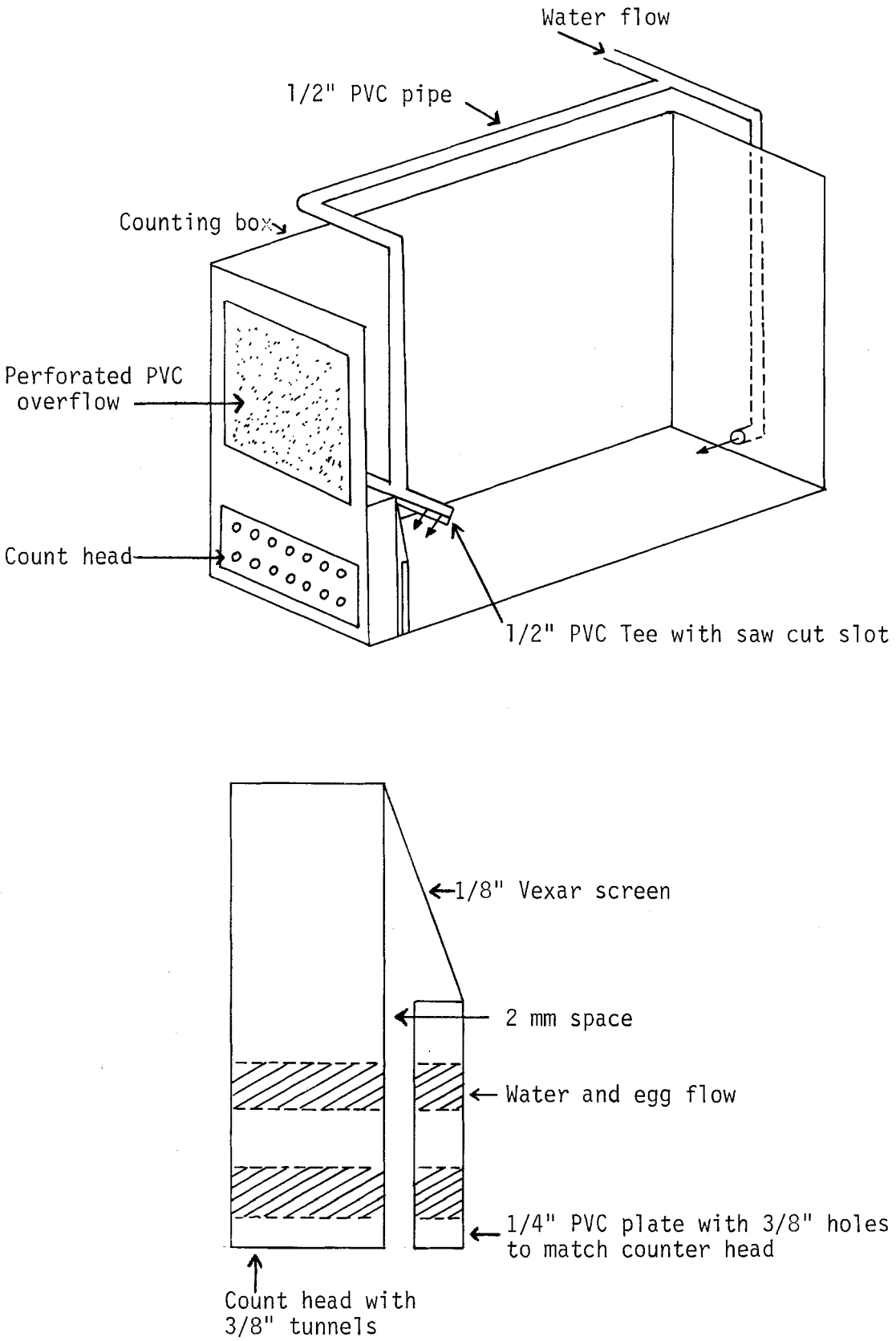
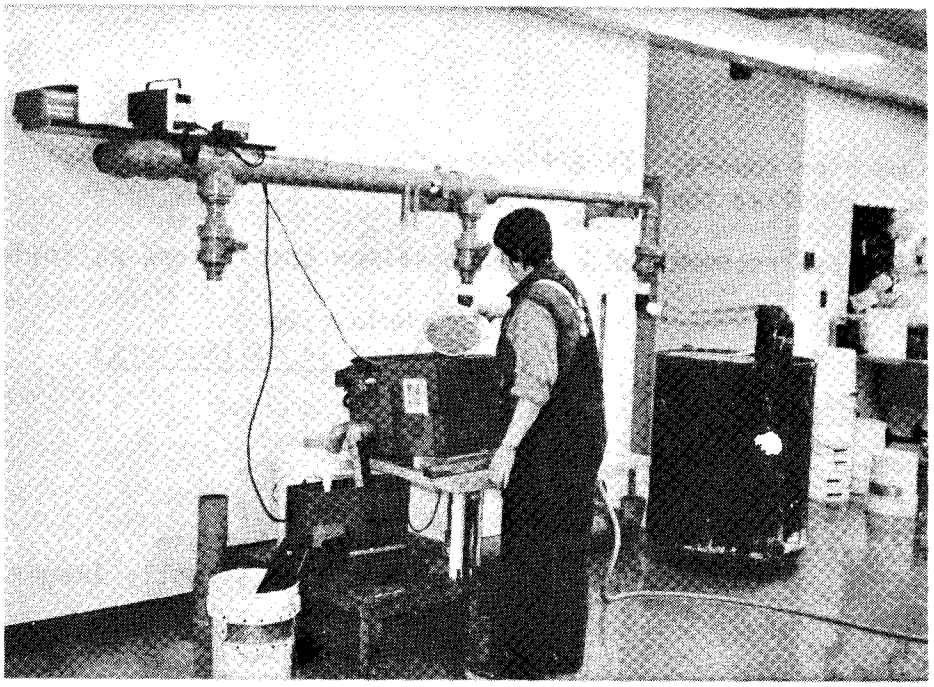
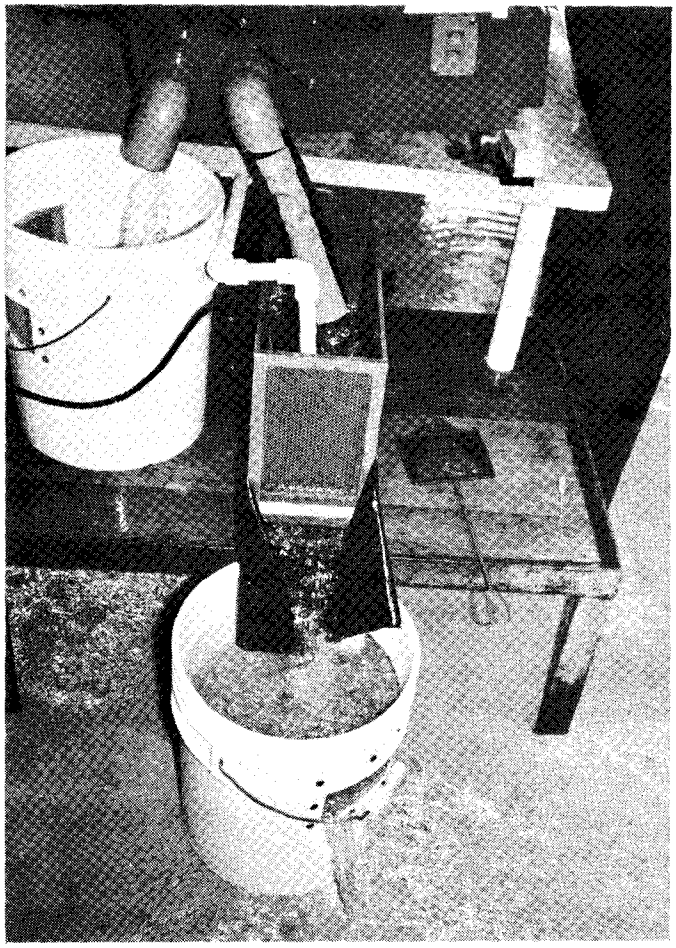
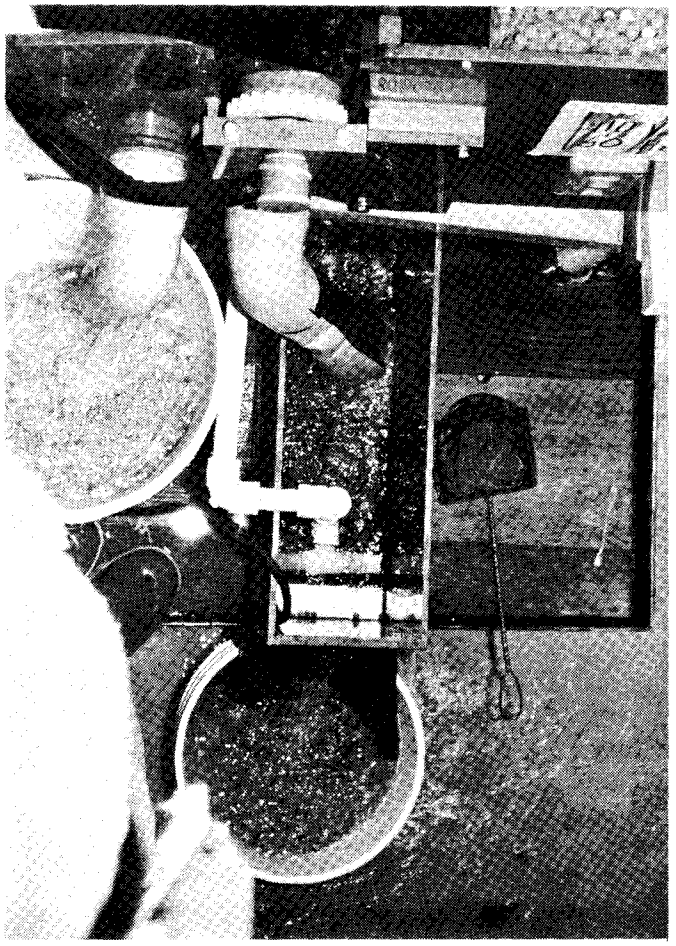


Figure 5. The electronic live egg counting unit with components.



Unsorted eggs are held in the cylindrical incubator at right. Eggs are placed into the Sustaf egg basin for sorting. Note the counter display (unit with the handle) at the top left side.





Front and top views of the counting unit in action. Eggs and water move smoothly from the Sustaf through the counting unit.

Figure 6. The Sustaf egg sorter and electronic live egg counting process.

eggs each with machine counts. In all cases (more than five samples), the machine count equalled the hand count.

Egg counter hole sizes recommended with each salmon species are as follows:

Species	Hole size (diameter in millimeters)
pink	8
chum	9.5
chinook	9.5 or 12.7
coho	9.5 or 12.7
sockeye	unknown, but use hole size slightly larger than egg

Sustaf Vendor

The sole North American vendor for Sustaf egg sorting machines is:

Troutsprings, Inc.
P.O. Box 11
McMillin, Washington 98352
Contact: Russell or Ed McLeary
Telephone: (206) 863-0446 or
(206) 922-5241

Each machine comes with two drums. Be sure to specify the correct hole sizes for the size of eggs. There are three drum hole sizes. A handy tool kit, and instruction manual comes with each machine.

RECOMMENDATIONS

The following recommendations regarding the use of Sustaf egg sorting machines arose from this successful workshop.

1) Clean up after each use will enhance Sustaf performance.
2) Spare parts for the Sustaf are required at all remote hatcheries.
3) Machines should not be transferred between hatcheries to avoid fish disease transfer.
4) At large hatcheries, an auxiliary egg hopper will enhance Sustaf efficiency.
5) Electronic counters are necessary for rapid, accurate counting of live eggs.

ACKNOWLEDGEMENTS

This workshop was successful because of the cooperation and contributions of all who attended. These folks were:

Name	Agency	Title	Location
Starr Busch	Montgomery Ward	Electronics Repairman	Anchorage AK
Bill Townsend	Troutlodge	Production Manager	McMillin WA
Mike Lindgren	SSRAA[2]/	Fish Culturist	Ketchikan AK
David Gaither	ADF&G (FRED)[3]/	Senior Culturist	Anchorage AK
Joe Sullivan	ADF&G (FRED)	Fish Pathologist II	Anchorage AK
Charles Hillman	ADF&G (FRED)	Maintenance Worker	Cannery Creek Hatchery AK
Jim Smith	ADF&G (FRED)	Maintenance Mechanic II	Juneau AK
Jim Ehret	ADF&G (FRED)	Maintenance Worker	Main Bay Hatchery AK
Kevin Smith	ADF&G (FRED)	Fish Culturist II	Hidden Falls Hatchery AK
Charles Scott	ADF&G (FRED)	Maintenance Worker	Anchorage AK
Ron Davis	ADF&G (FRED)	Fish Culturist V	Main Bay Hatchery AK
Tim Joyce	ADF&G (FRED)	Fish Culturist V	Kitoi Bay Hatchery AK
Clayton Brown	ADF&G (FRED)	Fish Culturist V	Russell Creek Hatchery AK
Paul Novak	ADF&G (FRED)	Fishery Biologist III	Ketchikan AK
Irl Palmer	ADF&G (FRED)	ADF&G Technician III	Juneau AK
Peter Rob	ADF&G (FRED)	Fish Culturist III	Sikusuilaq Springs Hatchery AK
Darrell Keifer	ADF&G (FRED)	Fish Culturist II	Anchorage AK
Bernard Kepshire	ADF&G (FRED)	Principal Fish Culturist	Juneau AK

2/ Southern Southeast Regional Aquaculture Association.
3/ Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development.

APPENDIX A

Circuit boards' schematics and parts list for Sustaf egg sorting machines.

Schematic for Semi-conductor Circuit Boards - Top Board and Front Panel for Sustaf 10^6, Sustaf-mini

Top Board

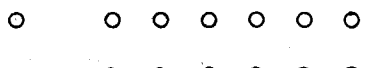
Bottom Side

Capacitor

0.1µf
160 V

A-1
SPRAGUE 2PS-P10
0.1µf± 10% 200 DC

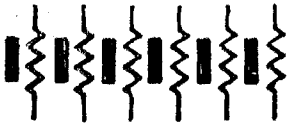
Top Side



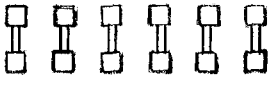
A-2 LED Lamps 0.200 Red
Jim Pack XC 556 R

A-3 LED Lamps 0.200 Green
Jim Pack XC 556 G

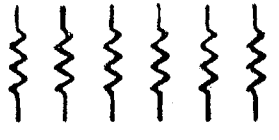
A-4 - Diode
Jim Pack IN 4004
400 PIV 1 Amp
Rectifier



A-5 Resistor
Jim Pack 1500 Ohms ± 5%



A-6 Final Transistor
Hamilton-Avnet VN 66 AF

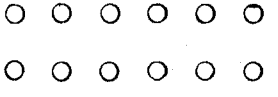


A-7 Resistor
Jim Pack 100,000 Ohms ± 5%

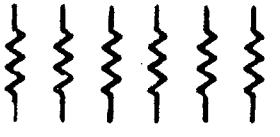
Front Panel

A-8 Lamp
North American Phillips OP 166

A-9 Capacitor
TRW PW5 5W

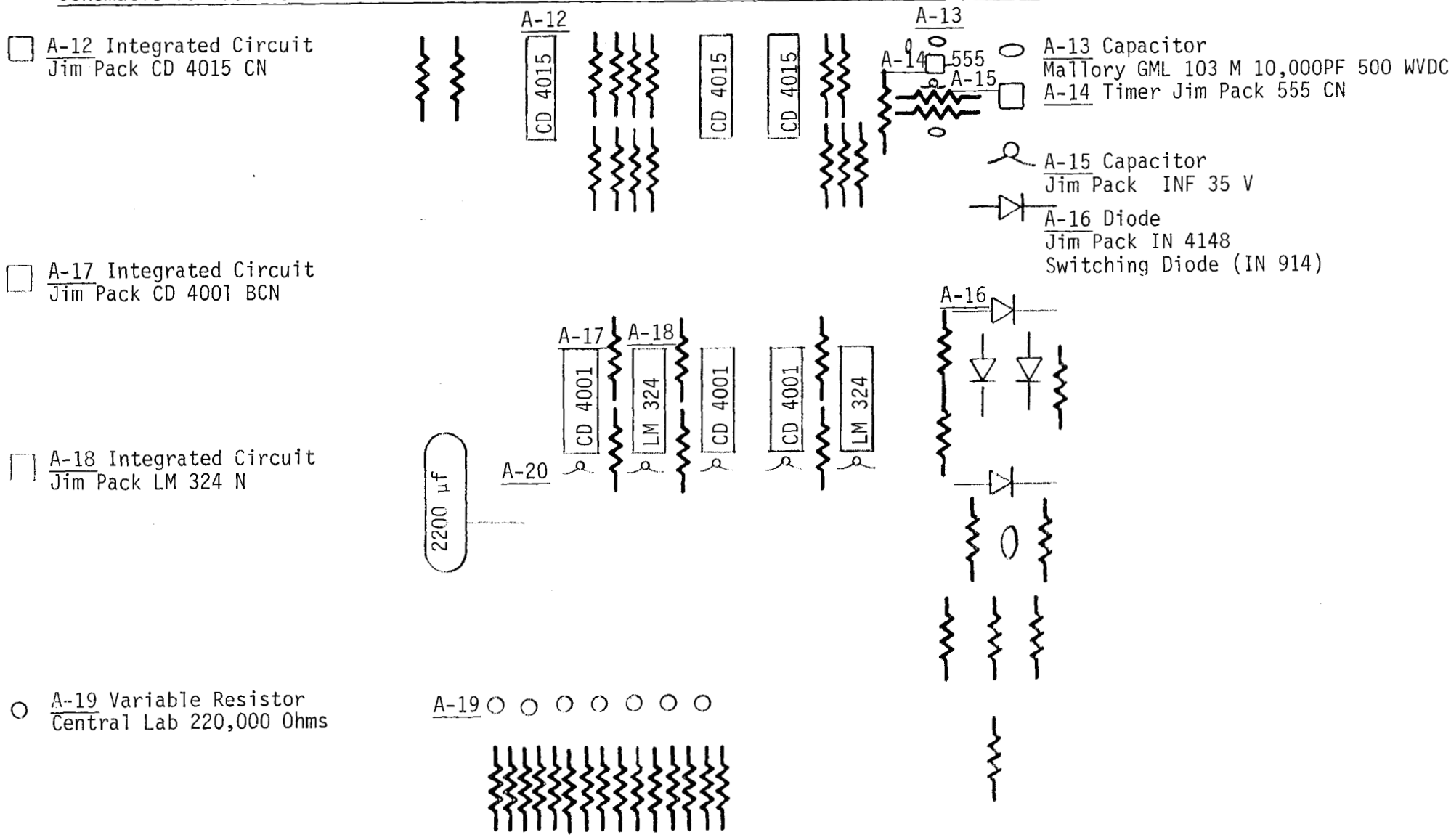


A-10 Lamps
North American Phillips
OP 166
OP 805



A-11 Resistor
Jim Pack 330 Ohms ± 5%

Schematic for Semi-conductor Circuit Boards - Bottom Board for Sustaf 10^6, Sustaf-mini



A-12 Integrated Circuit
Jim Pack CD 4015 CN

A-13 Capacitor
Mallory GML 103 M 10,000PF 500 WVDC

A-14 Timer Jim Pack 555 CN

A-15 Capacitor
Jim Pack INF 35 V

A-16 Diode
Jim Pack IN 4148
Switching Diode (IN 914)

A-17 Integrated Circuit
Jim Pack CD 4001 BCN

A-18 Integrated Circuit
Jim Pack LM 324 N

A-19 Variable Resistor
Central Lab 220,000 Ohms

A-20 Capacitor
Sprague 220 µf 16WF

Parts List for Semi-conductor Cirucit Boards-Electronic Box Sustaf 10^6 and Sustaf-mini

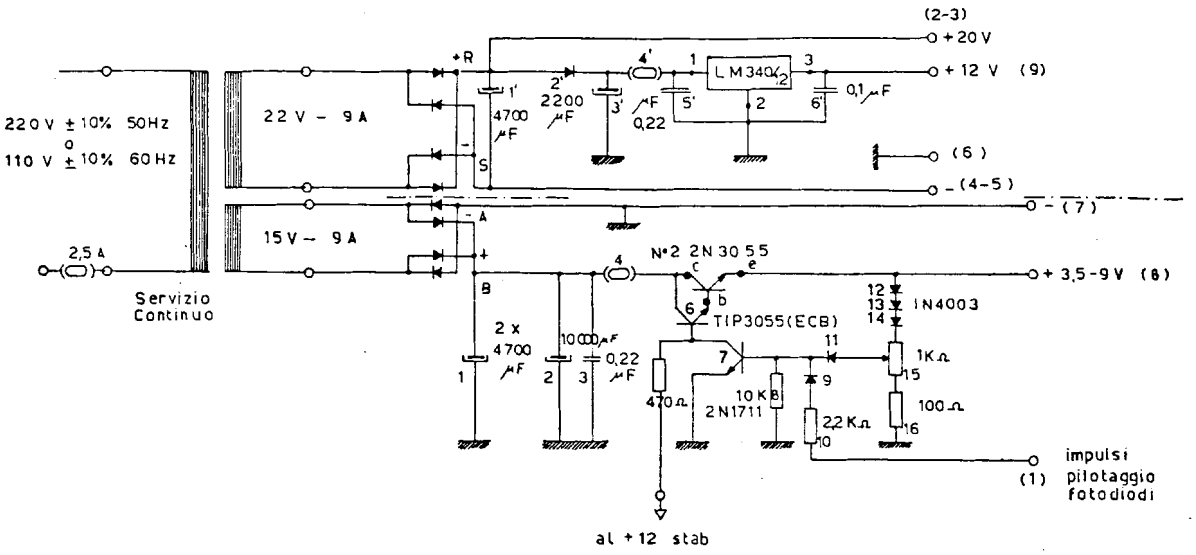
A-1	Capacitor - SPRAGUE 2PS-P10 0.1 µf ± 10% 200 DC
A-2	LED Lamps 0.200 Red JIM PACK XC 556 R
A-3	LED Lamps 0.200 Green JIM PACK XC 556 G
A-4	Diode JIM PACK IN 4004 400 PIV 1 Amp Rectifier
A-5	Resistor JIM PACK 1500 Ohms ± 5%
A-6	Final Transistor HAMILTON-AVNET VN 66 AF
A-7	Resistor JIM PACK 100,000 Ohms ± 5%
A-8	Lamp NORTH AMERICAN PHILLIPS OP 166
A-9	Capacitor TRW PW5 5W
A-10	Lamps NORTH AMERICAN PHILLIPS OP 166 and OP 805
A-11	Resistor JIM PACK 330 Ohms ± 5%
A-12	Integrated Circuit JIM PACK CD 4015 CN
A-13	Capacitor MALLORY GLM 103 M 10,000 PF 500 WVDC
A-14	Timer JIM PACK 555 CN
A-15	Capacitor JIM PACK INF 35 V
A-16	Diode JIM PACK IN 4148 Switching Diode (IN 914)
A-17	Integrated Circuit JIM PACK CD 4001 BCN
A-18	Integrated Circuit JIM PACK LM 324 N
A-19	Variable Resistor CENTRAL LAB 220,000 Ohms
A-20	Capacitor SPRAGUE 2200 µf 16WF

*Please note that there are several different brand names for the parts listed above. Those names underlined indicate just one brand name for the part, however, your local electronic shop should be able to identify other brand name parts by using those listed above.

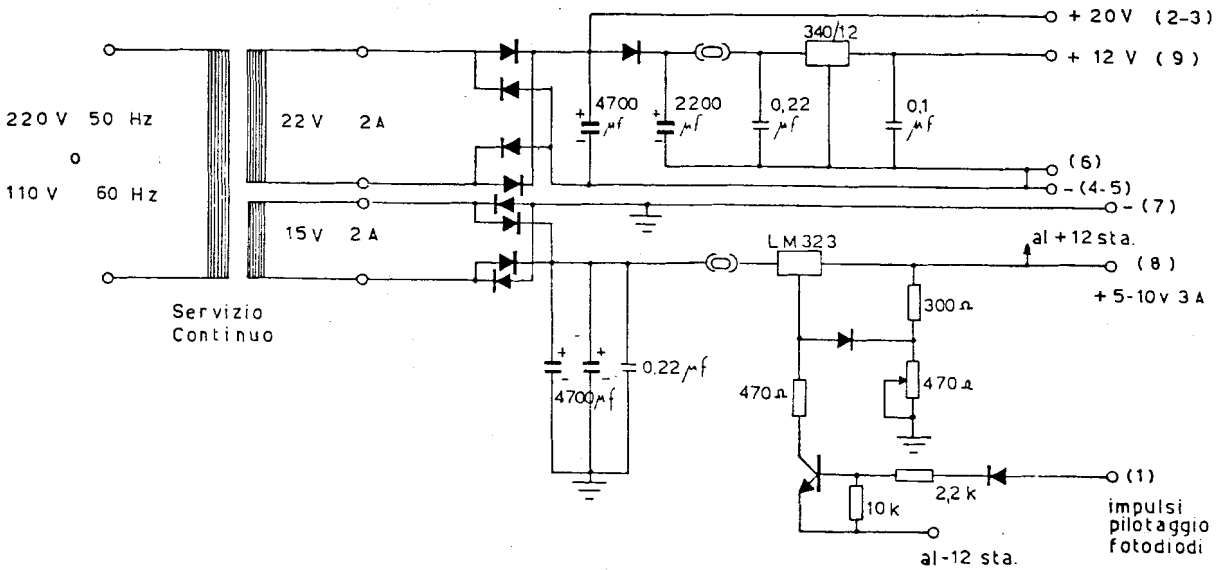
APPENDIX B

Power supply wiring diagrams, schematics, and parts lists for Sustaf egg sorting machines.

SUSTAF 10^6



SUSTAF-MINI



Power supply wiring diagram for Sustaf egg sorting machines.

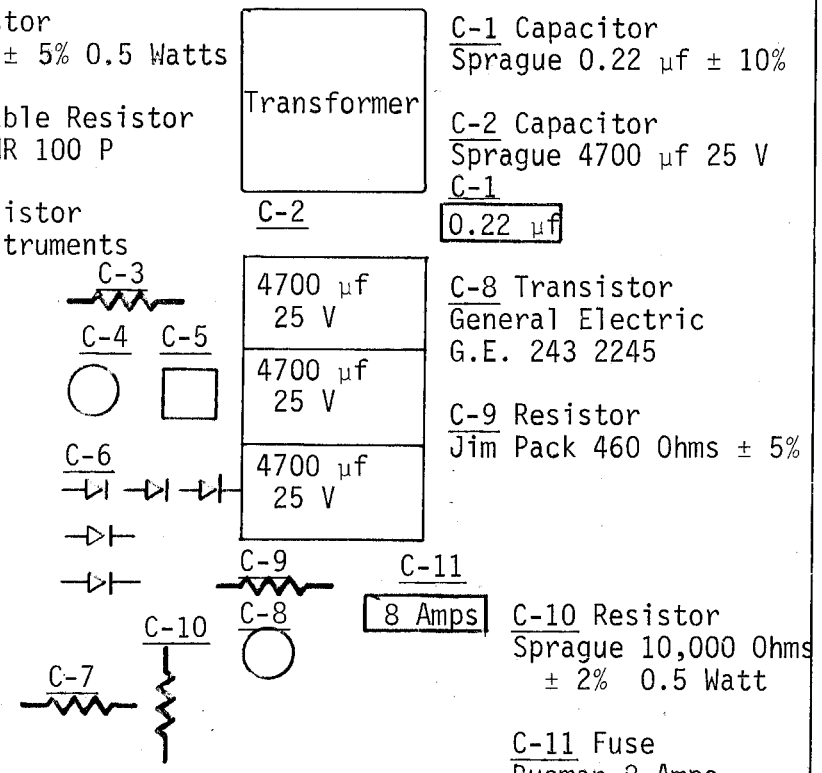
Schematic for Power Supply - Sustaf 10^6

Left Side

C-3 Resistor
470 Ohms ± 5% 0.5 Watts

C-4 Variable Resistor
Mallory MR 100 P

C-5 Transistor
Texas Instruments
TIP 3055



C-1 Capacitor
Sprague 0.22 µf ± 10%

C-2 Capacitor
Sprague 4700 µf 25 V

C-1
0.22 µf

C-8 Transistor
General Electric
G.E. 243 2245

C-9 Resistor
Jim Pack 460 Ohms ± 5%

C-10 Resistor
Sprague 10,000 Ohms
± 2% 0.5 Watt

C-11 Fuse
Busman 8 Amps

C-6 Diode
Jim Pack IN 4004

C-7 Resistor
Sprague 2200 Ohms 0.25 Watt

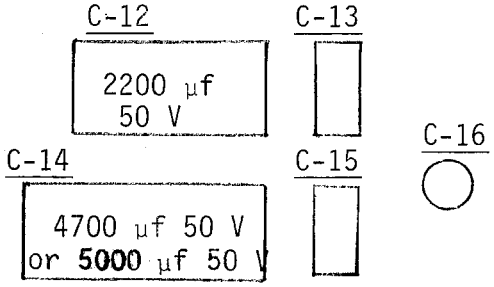
Right Side

C-12 Capacitor
Sprague 1318.20
2200 µf 50 V

C-13 Capacitor
Sprague 0.22 µf ± 10%

C-14 Capacitor
Sprague
5000 µf 50 V

C-15 Capacitor
Sprague 0.10 µf ± 10%

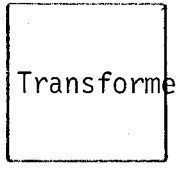


C-16 Voltage Regulator
National Semiconductor
LM 340 K-12

C-17 Diode
Jim Pack IN 4004

C-18 Fuse
Busman 2.5 Amps

In Heat Sink



C-19 Bridge Rectifier
Jim Pack MDA 980-3

C-20 Transistor
General Electric
2N 3055

Parts List - Power Supply Sustaf 10^6

C-1	Capacitor SPRAGUE 0.22 µf ± 10%
C-2	Capacitor SPRAGUE 4700 µf 25 V
C-3	Resistor 470 Ohms ± 5% 0.5 Watt
C-4	Variable Resistor MALLORY MR 100 P
C-5	Transistor TEXAS INSTRUMENTS TIP 3055
C-6	Diode JIM PACK IN 4004
C-7	Resistor SPRAGUE 2200 Ohms 0.25 Watt
C-8	Transistor GENERAL ELECTRIC G.E. 243 2245
C-9	Resistor JIM PACK 460 Ohms ± 5%
C-10	Resistor SPRAGUE 10,000 Ohms ± 2% 0.5 Watt
C-11	Fuse BUSMAN 8 Amps
C-12	Capacitor SPRAGUE TVA 1318.20 50 V 2200 µf
C-13	Capacitor SPRAGUE 0.22 µf ± 10%
C-14	Capacitor SPRAGUE 5000 µf 50 V
C-15	Capacitor SPRAGUE 0.10 µf ± 10%
C-16	Voltage Regulator NATIONAL SEMICONDUCTOR LM 340 K-12
C-17	Diode JIM PACK IN 4004
C-18	Fuse BUSMAN 2.5 Amps
C-19	Bridge Rectifier JIM PACK MDA 980-3
C-20	Transistor GENERAL ELECTRIC 2N 3055

*Please note that there are several different brand names for the parts listed above. Those names underlined indicate just one brand name for the part, however, your local electronic shop should be able to identify other brand name parts by using those listed above.

Schematic for Power Supply - Sustaf-mini

Left Side

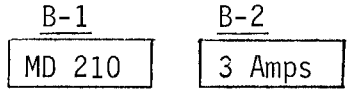
B-1 Bridge Rectifier
In-line Package
Motorola MD 210

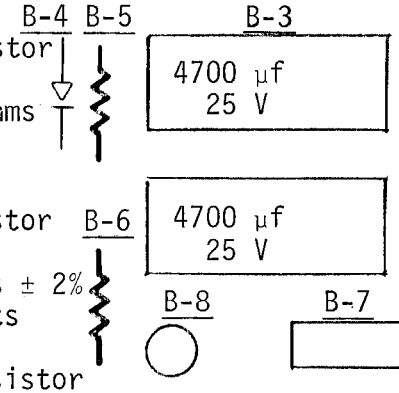
Transformer

B-2 Fuse Busman 3 Amps

B-3 Capacitor
Sprague 4700 µf 25 V

B-4 Diode
Jim Pack
IN 4004



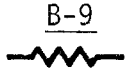


B-5 Resistor
Sprague
10,000 Ohms
± 2%
0.5 Watt

B-6 Resistor
Sprague
2200 Ohms ± 2%
0.25 Watts

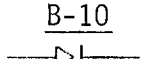
B-7 Capacitor
Sprague 0.22 µf ± 10%

B-8 Transistor
General Electric
G.E. 243 2245



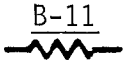
B-9 Resistor
Sprague
330 Ohms ± 2%
1 Watt

B-11 Resistor
470 Ohms ± 5%
0.5 Watt

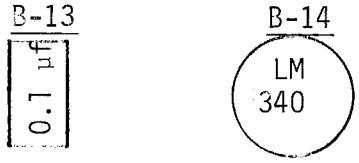


B-12 Variable
Resistor
Mallory MR 600 P

B-10 Diode
Jim Pack
IN 4004

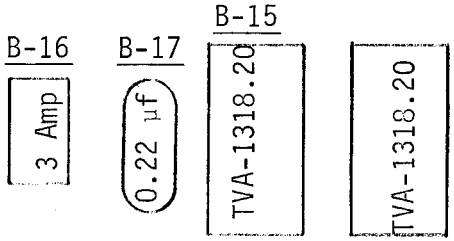


Right Side



B-13 Capacitor
Sprague 0.10 µf ± 10%

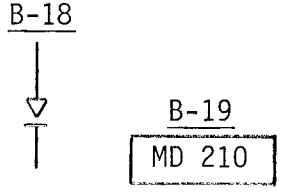
B-14 Voltage Regulator
National Semiconductor
LM 340 K-12



B-15 Capacitor
Sprague TVA 1318.20
2200 µf 50 V

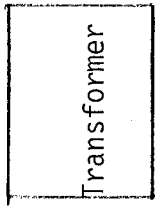
B-16 Fuse Busman 3 Amps

B-17 Capacitor
Sprague 0.22 µf ± 10%



B-18 Diode
Jim Pack IN 4004

B-19 Bridge Rectifier
In-line Package
Motorola MD 210



Parts List - Power Supply Sustaf-Mini

B-1	Bridge Rectifier In-line Package MOTOROLA MD 210
B-2	Fuse BUSMAN 3 Amps
B-3	Capacitor SPRAGUE 4700 µf 25 V
B-4	Diode JIM PACK IN 4004
B-5	Resistor SPRAGUE 10,000 Ohms ± 2% 0.5 Watt
B-6	Resistor SPRAGUE 2200 Ohms ± 2% 0.25 Watt
B-7	Capacitor SPRAGUE 0.22 µf ± 10%
B-8	Transistor GENERAL ELECTRIC G.E. 243 2245
B-9	Resistor SPRAGUE 330 Ohms ± 2% 1 Watt
B-10	Diode JIM PACK IN 4004
B-11	Resistor 470 Ohms ± 5% 0.5 Watt
B-12	Variable Resistor MALLORY MR 600 P
B-13	Capacitor SPRAGUE 0.10 µf ± 10%
B-14	Voltage Regulator NATIONAL SEMICONDUCTOR LM 340 K-12
B-15	Capacitor SPRAGUE TVA 1318.20 50 V 2200 µf
B-16	Fuse BUSMAN 3 Amps
B-17	Capacitor SPRAGUE 0.22 µf ± 10%
B-18	Diode JIM PACK IN 4004
B-19	Bridge Rectifier In-line Package MOTOROLA MD 210

*Please note that there are several different brand names for the parts listed above. Those names underlined indicate just one brand name for the part, however, your local electronic shop should be able to identify other brand name parts by using those listed above.